which the instructor personally guides the student along lines of special investigation. Seven general subjects were treated during this session, i. e., biochemistry, agronomy, horticulture and plant physiology, dairy husbandry and dairying, poultry husbandry, veterinary medicine, entomology. For each of these subjects there were one or two morning hours for lectures and two afternoon hours for seminars. There were, moreover, special Saturday exercises and popular lectures on Wednesday and Friday evenings.

Altho climate, i. e., sunshine and weather, are of vital importance in agriculture, yet we find but little mention of this subject in the program. The nearest approaches to it are the following topics:

C. G. Elliott: Drainage of land.
S. Fortier: Irrigation problems.
L. J. Briggs: Environment; Evaporation; Solar energy.
L. B. Judson: Effect of acetylene light.
G. H. Powell: Storage and transportation.
J. C. Whitten: Phenology.
J. G. Needham: What shall be done with the marshes?

This omission of the study of climatic conditions is doubtless due to the fact that man can not easily change or experiment with the local climate; he must adapt his methods and plants to the climate, and must achieve success in spite of the current weather.

Possibly climatic influences on crops are not yet sufficiently understood to warrant an attempt to diffuse exact knowledge on this subject. Possibly we have been attaching undue importance to natural climate, i. e., weather and sunshine, as compared with man's modifications of soil and cultivation and the artificial evolution of varieties adapted to the locality.

It is true that during the growing season in any locality there must needs be few frosts, sufficient rain or irrigation water, abundant sunshine and heat. These factors, notwithstanding their large annual variations, are usually so balanced that skilful cultivation and manuring insures a good crop. The work done by man is as essential as that done by nature, so that it is not fair for man to grumble at nature if he fails to raise a good crop.

However, without urging the agriculturist to give climatology a more prominent place in his postgraduate school of agriculture, we must profit by the good example he has set us and, as meteorologists, urge that there be also established a postgraduate school for advanced study in our own important branch of science.

The undergraduate and elementary courses pursued in American colleges and high schools, the various miscellaneous courses of lectures and instruction offered and maintained by the forecasters, section directors, and professors of the Weather Bureau under disadvantageous circumstances, all need to be supplemented by additional facilities. The importance of our subject may be brought into discredit by imperfect presentation.

We believe that there may be as many as fifty or one hundred persons in the United States who would embrace an opportunity to spend a month of strenuous effort in bringing themselves up to a higher standard of knowledge concerning climates and weather. It may be that the Secretary of Agriculture and the Chief of the Weather Bureau have no legal authority to establish such special courses of technical instructions. Congress has imposed on them only the duty of utilizing for the public benefit what little we know of agriculture and meteorology, and they can do little beyond this. But as it *is* their duty both to make new discoveries, to increase knowledge and to disseminate it among the citizens, therefore they should be allowed to carry on every method that gives promise of accomplishing these desirable results.

Now the "seminar" that forms such a predominating part of the work of the Graduate School of Agriculture, is more precisely a daily conference between the advanced pupil and the master who is a little way ahead of his pupil. The master undertakes to show the pupil just how important items of our knowledge have been obtained, but the pupils ask many questions, and it is a dull master who does not perceive when his bright pupil is on the road to making some real addition to our knowledge. Not that he will open up a new world to us, but that he may at least settle accurately some point about which our present knowledge is rather hazy. It is thus that step by step they climb the hill of science together. Thus the muses who bear the torches of knowledge light the lamps of the children of men. Thus we learn to see with the eye of the telescope and the microscope, and to feel with the fingers of the scale beam and the standard gage.

How can an annual meeting be arranged covering some weeks of daily lectures and conferences between our older and younger meteorologists, at which each shall give to the other of his store of wisdom and experience? Six hundred Weather Bureau observers and employees, 2,500 cooperative observers, 5,000 teachers, and 100,000 pupils are interested in propositions such as this which contemplates decided advances in meteorology. At present we rely too much on books and letters; we shall do better to get together, ask questions, try experiments, and compare notes.—*C. A.*

PROGRESSIVE CLIMATIC VARIATIONS ON THE ISTHMUS OF PANAMA.[1]

By Brig. Gen. HENRY L. ABBOT, U. S. Army, retired, late member, Board of Consulting Engineers. Dated Cambridge, Mass., June 12, 1908.

The study of progressive variations in physical quantities admitting of measurement has largely contributed to the advance of science. For example, that the so-called solar constant of radiation is subject to progressive changes, involving a small temperature fluctuation upon the earth nearly simultaneous with the sun-spot cycle, has been suggested by recent astrophysical researches supplemented by elaborate studies of temperature records at coast and specially at inland stations.

It is well known that the movement of the sun in declination regulates in a marked degree the precipitation upon the Isthmus of Panama, causing annually a normal succession of dry and rainy months as, carrying its rainbelt, it oscillates between the Tropics; and it would seem to be of interest to determine, as well as existing data will permit, whether there are other periodic changes in the Isthmian climate for which perhaps an explanation may be found.

But aside from the purely scientific interests of the question a knowledge of any periodic variations in rainfall, entailing corresponding changes in the volume carried by the Chagres River, is locally important from its bearing on the water supply of the canal, as well as upon the probable conditions attending its construction in the immediate future. That the de Lesseps Company worked under specially unfavorable climatic conditions is an historical fact, and the probabilities for the next few years are well worthy of investigation.

The records available consist of nearly continuous rainfall measurements at Colon made by the Panama Railroad Company from 1863 to 1874, inclusive; those made later at Colon and Gamboa by the two Canal companies and the Liquidation from 1881 to the transfer of the property to the United States in 1904; and those continued to date by the Isthmian Canal Commission. The Colon rainfall records for the years 1875 to 1880, inclusive, are quoted from Plate XXXVIII of Part IV of the Twenty-second Annual Report of the U. S. Geological Survey, the authority not being stated. Closely related to these data are the fluviograph records of water heights at Gamboa which are nearly continuous since 1882. These auto-

[1] Earlier papers on Isthmian rainfall may be found in Monthly Weather Review, February, 1907, XXXV, p. 74, 75.

matic records furnish, monthly, precise information as to the number of freshets and the number of hours during which the water level rose above the normal stand adopted as the lower freshet limit, this limit being about 10 feet above dead low water in the river, or 17 meters above mean tide, which is the same in both oceans. Below this level the Chagres River is a gentle stream ranging in discharge between 350 and 1,150 cubic feet per second, while in the freshets of the rainy season it often attains during twenty-four hours a volume of 15,000 to 30,000 and in greater floods even 60,000 cubic feet. With such a regimen the relative monthly discharge becomes practically a function of the number of these freshets and of their duration, and a knowledge of the latter gives the basis for a trustworthy estimate of the relative monthly flow of the stream. This knowledge we have since January, 1883, except for the years 1889 and 1896. Finally, we have nearly continuous gagings of the daily outflow from the basin above Bohio (about 700 square miles) since January, 1890; and, since January, 1898, a precise knowledge both of the downfall and of the outflow, the former based on rainfall records well distributed thruout the basin. It remains to consider how these data can be coordinated to exhibit any progressive climatic change for as many years as possible.

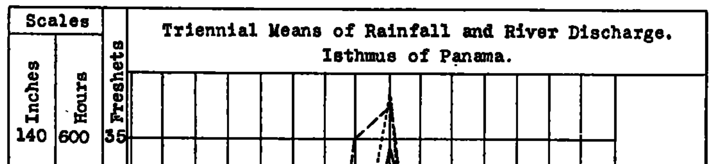

FIG. 1.

As stated above, the annual rainfall records begin at Colon in 1863, and at Colon and Gamboa, jointly, in 1881. It is, however, desirable to know not merely the amount of local downfall, but how much fell over a considerable area such as the basin above Bohio; whether this can be derived logically from the data for the early years is the first point to consider.

Rainfall on the Isthmus is greatest near the Atlantic coast, where it averages about 130 inches, and is least near the Pacific coast, where it averages about 60 inches; in the interior it falls off gradually from one to the other. The basin above Bohio touches the district of Atlantic coast precipitation both at Bohio and at the headwaters of its chief branch, the Pequeni, while Gamboa lies in the interior at a point of the basin most nearly approaching the Pacific coast. These facts suggest that perhaps it may be possible to form an approximate estimate of the downfall over the whole basin from the known figures at Colon and Gamboa, in other words, to generalize the local data. This question may be determined by a study of the complete 10-year record.

During these ten years (1898–1907) the average annual rainfall at Colon was 121.7 inches, at Gamboa, 87.2 inches, and over the entire basin above Bohio, 107.8 inches; this would suggest that the latter is about 89 per cent of that at Colon, 124 per cent of that at Gamboa, and 52 per cent of the aggregate at the two stations. A test of these coefficients was made by applying them to each of the ten yearly records, and comparing the computed results for the entire basin with the known true values. The probable error for a single result proved to be for a Colon record 9.48 inches (9 per cent), for a Gamboa record 6.32 inches (6 per cent), and for an aggregate record 6.12 inches (6 per cent). Such probable errors are quite within limits when dealing with general rainfall estimations, and the above coefficients have been used in preparing the following table. When records at both stations are available, preference has always been given to the value found by taking 52 per cent of their sum. Indeed this is practically equivalent to adopting the average of the two stations; and their geographical location, as shown above, would suggest that such an average should give a fairly good idea of the downfall over the entire basin, which is what is wanted for the rainfall element. The other data require no explanation. Table 1 presents their analysis.

TABLE 1.—*Rainfall, runoff, and freshets, Isthmus of Panama.*

Year.	Precipitation.		In basin above Bohio.			Freshets at Gamboa.		Remarks.
	Colon.	Gamboa.	Rainfall.	Outflow.		Annual.	Duration.	
	Inches.	*Inches.*	*Inches.*	*Feet-secs.*	*Inches per square mile.*	*No.*	*Hours.*	
1863..	129.8	......	115	......	......	......	......	Records of Panama Railroad.
1864..	106.9	......	95 } 102	......	......	......	......	
1865..	107.4	......	96	......	......	......	......	
1866..	129.7	......	115	......	......	......	......	
1867..	86.5	......	77 } 100	......	......	......	......	
1868..	120.0	......	107	......	......	......	......	
1869..	114.8	......	102	......	......	......	......	
1870..	149.6	......	133 } 105	......	......	......	......	
1871..	99.6	......	81	......	......	......	......	
1872..	168.5	......	150	......	......	......	......	
1873..	87.1	......	78 } 117	......	......	......	......	
1874..	137.7	......	123	......	......	......	......	
1875..	94.7	......	84	......	......	......	......	22d Ann. Rep. U. S. Geol. Survey, Part IV. Plate.
1876.	124.5	......	111 } 99	......	......	......	......	
1877..	115.4	......	103	......	......	......	......	
1878..	86.7	......	77	......	......	......	......	
1879*.	146.2	......	130 } 110	......	......	......	......	
1880.	136.4	......	121	......	......	......	......	
1881..	102.3	89.5	100	......	......	...	...	Records of the canal.
1882..	124.1	79.6	106 } 102	......	......	... } 21	... } 201	
1883..	115.3	76 6	100	......	......	21	201	
1884..	86.5	95.9	95	......	......	25	334	
1885*.	146.3	97.5	127 } 116	......	......	37 } 35	437 } 403	
1886..	137.2	102.9	125	......	......	43	437	
1887..	154.9	136.2	151	......	......	46	709	
1888*.	......	102.6	127 } 139	......	......	29 } 37	596 } 653	
1889..	......	†75.7	....	......	......	...	...	Collapse of first French Co. Liquidation.
1890*.	154.3	105.0	135	6,304	122.4	34	308	
1891..	124.7	77.7	105 } 123	4,476 } 5,764	96.8 } 111.8	10 } 23	116 } 231	
1892..	145.3	104.4	130	6,513	126.3	24	269	
1893*	131.9	117.8	130	7,081	137.4	12	220	
1894..	153.7	90.6	127 } 131	6,098 } 5,887	118.4 } 114.2	25 } 15	263 } 179	
1895..	151.5	......	135	4,482	86.9	7	54	New French Co.
1896..	131.5	......	117	4,216	81.8	..	...	
1897..	138.0	107.8	128 } 116	4,830 } 4,330	93.7 } 84.0	16 } 12	157 } 104	
1898..	115.5	82.6	103	3,944	76.5	8	51	
1899..	133.0	80.0	111	3,384	65.6	8	57	
1900..	116.1	78.7	101 } 106	3,509 } 3,583	68.0 } 69.5	12 } 11	84 } 83	
1901..	107.7	91.6	104	3,855	74.8	13	107	
1902..	112.6	97.7	109	4,179	81.1	5	37	
1903..	126.3	99.3	117 } 112	3,958 } 4,082	76.7 } 79.2	12 } 10	94 } 75	
1904..	126.9	84.5	110	4,110	79.7	13	94	United States in charge.
1905.	115.4	82.2	103	2,800	54.3	6	48	
1906*.	138.1	97.8	123 } 111	4,169 } 3,522	80.9 } 68.3	12 } 10	178 } 98	
1907..	125.6	78.1	106	3,597	69.8	11	69	

* Years of great floods; these are the only ones of record.
† Accuracy doubted.

It should be stated that the rainfall records up to 1903, except for the years 1875 to 1880, as quoted in the table, may be found in the form of monthly means in the MONTHLY WEATHER REVIEW for May, 1899, XXVII, p. 202–203, and March 1903, XXXI, p. 122. They are nearly complete, and fortunately the few months lacking are mostly in the dry season where they have little importance, and can be supplied accurately by interpolation based on months of about the same period. The freshet records are complete except for October, 1887, and August and September, 1897, which have been supplied by averaging those of the two nearest years. The gagings are complete, and to make the volume of the discharge directly comparable with that of the rainfall it is stated in inches per square mile per year as well as in cubic feet per second. In fine the records are essentially complete and trustworthy for the whole period under consideration. To make the progressive changes in the four elements more distinctly visible to the eye the years have been grouped by threes, both in the table and on fig. 1.

An inspection of this table, and of the figure illustrating it (fig. 1), can leave little doubt that during the last forty years there has been a well-marked gradual increase followed by a like decrease in the annual precipitation and in resulting river outflow; that a period not much if any above the minimum is now passing. The maximum epoch, as nearly as can be determined, occurred about twenty years ago when the de Lesseps Company was most actively at work; and at that date the annual rainfall in the basin above Bohio was fully one-quarter greater than the present. This maximum was preceded by a minimum at an interval of about twelve years, when the downfall appears to have differed little from what it is at present. Four different lines of evidence, in recent years, suggest these conclusions, and it may be noted that the figures of rainfall and outflow tend to support each other. Thus the difference between them, representing evaporation, diminishes as the rainfall increases. Direct observation at the Isthmus in 1907 showed that monthly evaporation from exposed water surfaces in the rainy months is only about 60 per cent of what it is in the three dry months; and for the general surface of the country the difference should be even greater. A sensible reduction in evaporation as annual rainfall increases should therefore be anticipated, and this is what the figures show.

In fine, it would seem to be undeniable that long-period progressive variations do occur in the volume of Isthmian rainfall, and that at present a minimum epoch is passing. There are records of similar changes even in regions of moderate annual rainfall; as for example in the Croton Valley watershed, which supplies New York City with water, where during the last half of the 36-year period from 1869 to 1904 the precipitation is reported to have exceeded that in the first half by about 30 per cent. The causes of such variations are certainly an interesting subject for study, and for this the Tropics, where frost is unknown, offer special advantages.

The estimates for the water supply of the canal are based on the minimum measured flow of the Chagres River to date, and it is satisfactory to know that there is good reason to believe that this volume is practically an absolute minimum. Furthermore, from the form of the curve since the last maximum epoch it is reasonable to hope that time enough to complete the work may be available before the advent of the next maximum. Rainfall as great as that upon the Isthmus is a formidable obstacle to rapid prosecution both of excavation and of lock and dam construction.

SEVERE WINDSTORMS IN OHIO, JUNE 19, 1908.

By J. WARREN SMITH, Section Director. Dated Columbus, Ohio, July 14, 1908.

Very severe thundersqualls occurred in most sections of Ohio on the afternoon of June 19. Thunderstorms with high winds were noted in the western counties soon after 2 p. m., while the squalls did not reach the eastern counties until about 6:30 p. m. Their progress across the State is shown in fig. 1.

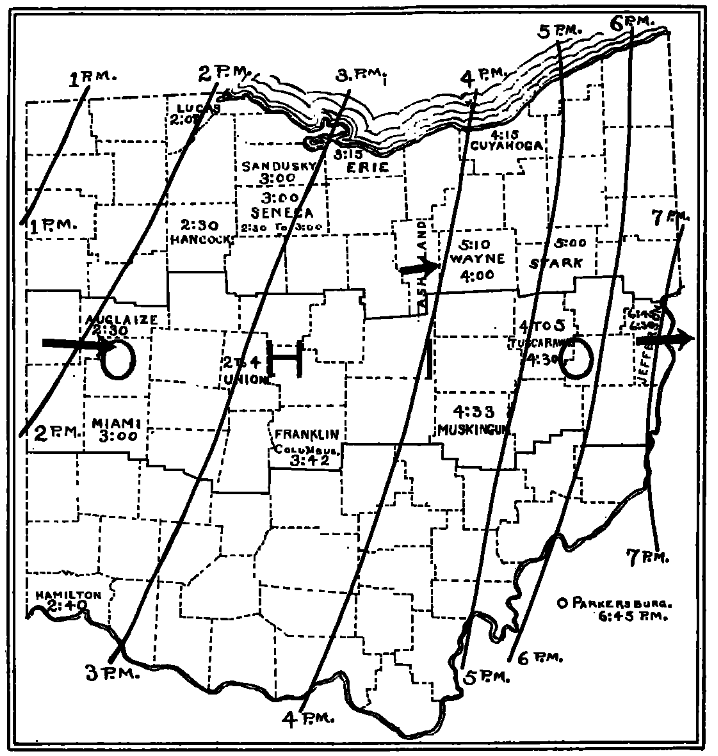

FIG. 1.—Map showing progress of severe windstorms across Ohio, June 19, 1908.

At Indianapolis, Ind., the first thunder was heard at 12:50 p. m. At Sandusky, Ohio, the wind reached a velocity of 26 miles an hour at 3:15 p. m. At Columbus it blew at the rate of 64 miles an hour for three minutes at 3:42 p. m. At Cleveland the highest wind was 52 miles an hour at 4:15 p. m., at Parkersburg, W. Va., 30 miles an hour at 6:45 p. m., and at Pittsburg, Pa., 43 miles an hour at 7:15 p. m.

The damage to fruit and forest trees, fences, telephone and telegraph wires, and buildings was widespread, but from reports received the greatest damage seems to have been in Auglaize, Hancock, Sandusky, Tiffin, Ashland, Wayne, Tuscarawas, and Jefferson counties.

Mr. Jacob Bornbeck, who lived near Canal Winchester in Tuscarawas County, was crushed and killed in the ruins of his barn that was blown down. Quite a number of people were injured in various parts of the State.

Miss Lillian Grothaus of New Bremen reports that a well-defined funnel-shaped tornado cloud, with rotary winds, occurred near Minster, in Auglaize County. The color of the cloud was greenish and yellow. The path of the tornado was about one mile in length and one-half mile in width.

Mr. Martin J. Hoffmann of Loudonville, Ashland County, reports that a tornado past thru the northern part of that place. One building was demolished and other damage was done. The path of greatest damage was about one-half mile in length and about 80 feet in width. Its direction was slightly to the north of east. A typical funnel-shaped cloud was visible and was observed by several people.

A great deal of damage was done in southern Sandusky and northern Seneca counties, but the reports indicate that the wind was a straight-line squall and not a tornado.

Near Wooster, in Wayne County, the horse and buggy with which Dr. W. F. Derr was driving was picked up by the wind, carried across the ditch, and landed bottomside up against the fence. The path of the greatest damage at this place was